

Investigation of Future Building Performance Factors Towards Energy Efficient Travel Plan in Regional Development

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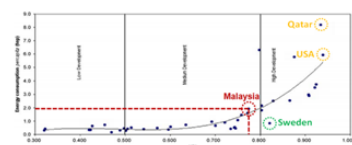
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Graphical abstract



Abstract

Preliminary research shows the shortcoming of Building Performance field of research to measure outdoor performance of building mainly EETP factors. Accordingly, this research aimed at proposing a future building performance towards Energy Efficient Travel Plan (EETP) based on user friendly EETP factors. The research methodology engaged three research phases. Phase I was to identify user friendly EETP factors. In this phase after a literature review, fix-format self reporting interview survey was conducted among experts in Travel Plan implementation in Malaysia. 'Phase II' was to investigate effective Building performance factors on user friendly EETP, within the literature review conducted on building performances followed by brainstorming with 5 experts in building management field of research. Final phase was to validate the proposed building performance towards EETP in a futuristic cross-impact scenario study. In summary, this research introduced three main outcomes, first: a list of user friendly EETP factors, second: EETP building performance factors and Third: future building performance factors towards EETP based on futuristic cross-impact analysis. In conclusion, this study introduced lists of new innovative future building performances including: BCS (Building Communication System), BEEM (Building Energy Education Management), EETP (Energy Efficient Travel Plan), BRc.S (Building Recycling System), and BAgr. (Building Agriculture) investigated as future building performance factors.

Keywords: Building performance factors; energy efficient travel plan; regional development

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1.0 INTRODUCTION TO ENERGY EFFICIENT TRAVEL PLAN

Energy Efficient Travel Plan (EETP) is under the umbrella of Travel Plan (TP) introduced by science in the late 90's. Traditionally, TP provides policy planning to reduce transportation impact. Enoch and Ison¹ define TP as "a long-term management strategy for an organization and its various sites or business park that seeks to deliver transport objectives through positive action and is articulated by a document that is regularly reviewed".

Wake *et al.*² define TP as "...a package of actions implemented to manage travel generated by a workplace. Primarily, travel plans seek to reduce car trips and encourage the use of lower impact alternatives, such as walking, cycling, public transport and telecommunications."

Rye³ states that TP in UK is known as company (workplace) travel plan, while in Europe it is known as mobility management,

and in US it is known as transportation demand management (TDM). Albeit, the three concepts are addressing the same issue, this study used TP and EETP as referred to in the report. Table 1 addresses some of the measures in TP adapted from Rye³.

In TP mostly, the main concern is measuring, monitoring and reducing Carbon Foot Print of all the residents under the issue of TP. It is proposed normally in 'organizational bases'. Tyler *et al.*⁴ state that "...initially, travel plans were required by regulation in the US. The 1990 Clean Air Act Amendment required employers with 100 or more employees to implement trip reduction".

The travel sector is a challenging issue for urban and transportation planners, which are integrating the travelling and movement of both vehicles and passengers. However, vehicles are the main sources of CO₂ emissions in transportation and travelling sector. The controversial argument is that many technological innovations with the potential to reduce transportation emissions from passenger vehicles are possible but it needs more research

and investigations. However, consensus is growing that technological innovations alone will not be enough to reach targeted reductions in CO₂ emissions; changes in human behaviour are also essential^{5,6,7}. TP addresses this aim in principles.

Table 1 Travel plan measures (Adopted from Rye, 2002)

Mode	Measure
Overall for whole plan	<ul style="list-style-type: none"> – Travel coordinator (member of staff) – Promotion and publicity – Implementation process, e.g. steering group
Walking	<ul style="list-style-type: none"> – Improved lighting and walkways – Incentives for walkers – Crossings in/adjacent to site – Changing/shower facilities
Cycling	<ul style="list-style-type: none"> – Pool cycles – Bicycle loan scheme – Good, secure parking provision – Discount purchases of cycles and equipment – Provision of PT information at workplace
Public Transport	<ul style="list-style-type: none"> – Access to rail planner – Discounted season tickets, paid for by operator – Liaise with local operators to operate new services – Pay for new services – Pay for subsidies for fares on existing bus services – Staff travel survey to identify potential sharers – Priority parking spaces for car sharers – Guaranteed ride home (taxi)
Car share	<ul style="list-style-type: none"> – Reduce parking supply – Ration parking through permit allocation – Charge for parking – Flexi-time – Telecommuting/working
Parking	<ul style="list-style-type: none"> – Company car initiatives (phased out/ altered)

2.0 PROBLEM STATEMENT

This section explains the rationale behind this study; which is divided into two; gap in research on building performance factors to consider EETP and the need for practice of EETP.

2.1 Gap in Research on Building Performance Factors to Consider EETP

This research tries to introduce consequences of Energy Efficient Travel Plan (EETP) on Building Performance factors, as Future Building performance factors. Dorasol⁸ states that there are 15 building performance criteria to be considered as Building Performance Factors. He reviewed POE (Preiser, 2008), POE (Minnesota Univ., 2004), Building Quality Assessment (BQA), ISO 6241 Performance standards for buildings, Orbit 2.1, Facilities Performance Evaluation (FPE) and some other researchers' efforts and arrives at a total of 15 different evaluation criteria which includes; health, safety, security, functionality, efficiency, social, environmental psychology, aesthetics, operations, comfort, durability, economic, flexibility and culture. This study observes that all the above-mentioned performance factors are related to the indoor building and close outdoor of building alone, and no consideration is given to performance of building in area, especially, with regards to the responsibility of EETP. Besides, Intelligent Building concept, for more than thirty years, has been changing the building performance criteria, but with the direction of Energy Efficient Travel Plan (EETP), it

seems that it can do more to help the travel behaviour, and it can introduce new performance criteria to its designers and users.

2.2 The Need in EETP Practices

It is a common importance among all countries to improve Human Development Index (HDI) as a measure of human Quality of Life. The increase in HDI will have effect on higher energy consumption. Figure 1 highlights the correlation between HDI and Energy consumption contrast within various countries and shows the critical position of Malaysia. This confirms that Malaysia has to foresee the future energy consumption and optimize its energy consumption in sustainable building design framework towards improving quality of life.

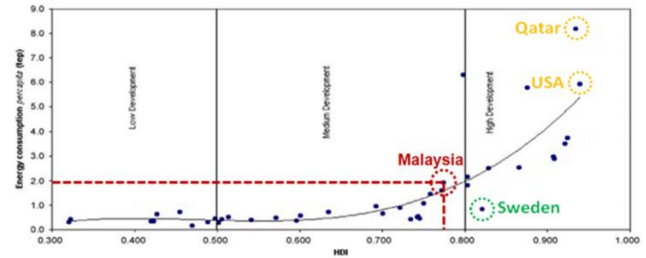


Figure 1 HDI versus Energy consumption within various countries (Adopted from Dias *et al.*⁹)

This momentum is obvious to the Malaysian government. The key Malaysian ministry and agency involved are the Ministry of Energy, Green Technology and Water, Energy Unit of Economic Planning Unit of Prime Minister's office, The Energy Commission of Malaysia, and Persatuan Tadika Malaysia (PTM). Furthermore, agendas have been set for each of the mentioned Malaysian ministry and agency through the five year base Malaysian plans. The Malaysian government in the Ninth Malaysia Plan focuses strongly on Energy efficiency programs while, "sustaining the quality of life for the needs of the population and at the same time to manage Malaysia's resources" (Ninth Malaysia Plan 2006-2010). Moreover, greater emphasis has been laid on energy efficiency under the Tenth Malaysia Plan (2011-2015).

In Malaysian building construction industry, environmental concerns, energy crisis, and technological advances, have brought up Energy Efficiency as the agenda for building performances since the 80's. In 1989, the Malaysian Ministry of Energy, Water and Communication (MEWC) had introduced the Guidelines for Energy Efficiency in Non-Domestic Buildings. The guidelines were revised as the Malaysian Standard MS 1525:2001 10 which aimed at encouraging the application of energy efficiency in new and existing buildings while maintaining comfort, health and safety of the building-users. Best practices as stipulated in the Malaysian Standard MS 1525:2007 "Code of Practice on Energy Efficiency and the Use of Renewable Energy for Non-Residential Buildings" have been adopted as guiding principles.

However, MS 1525:2007 in line with some internationally well-known standards (such as ASHRAE standard 55-2010, and ISO 11 7730:2005) does not support all requirements of building user in the energy efficiency. Indeed, updating and improving MS 1525:2007, with the existence of complimentary tools and framework is considerably needed to ensure that it continues to 'move forward' in energy efficiency standard of buildings in Malaysia.

Building based TP has potential towards energy efficiency. The behaviours underlying transportation foot print are complex. Vehicle-Miles-Travelling (VMT) is the direct result of a series of behavioural choices shaped by the physical environment and policy context over different time frames. The rate of emissions per mile is also fundamentally a function of behaviour, both the choice of vehicle type and the style of driving. As obvious, location and function of building have direct effect on this CO₂ emission.

Therefore, with investigating the effect of Building Performance on Sustainable Travel Plan in future urban mobility, we will have new feature in terms of opportunity of building to be part of EETP to eliminate and minimize the travel. Relatively, the research question is as followed:

“What would be the future of Building performance factors towards enhancing Energy Efficient Travel Plan?”

■3.0 AIM, OBJECTIVES AND SCOPE OF STUDY

This research project aims at proposing future building performance factors toward Energy Efficient Travel Plan. To address this aim, the following objectives were defined; firstly: to identify user friendly EETP factors, secondly: to investigate effective Building Performances (BP) towards user friendly EETP, and thirdly: to establish future Building Performances (BP) factors towards user friendly EETP. Several areas were investigated as scope in this study, including; building functionality, which was limited to cover only office buildings in Malaysia and from other possible regions, and the building performance investigated was limited to those with direct effect on EETP.

■4.0 SIGNIFICANCE OF STUDY

This study has been formulated in relation to BPs from EETP perspective. This investigation is fundamental for future buildings to be more Green and Sustainable. Currently, building construction industry is practicing sustainable building assessment (SBA) tools to benchmark sustainability in building 12. Social aspects also include the interrelation between single buildings and community-level issues like urban design quality, social segregation, urban sprawl, etc. The significance of the current research is to propose future BPs in EEB. Indeed, such BPs will open insight in building construction R&D and also towards building sustainable development. Introduction of BPs in this study is fundamental for R&D sector for further development of means to apply the BPs.

■5.0 RESEARCH METHODOLOGY

This study was developed along three research phases corresponding to the three objectives of the study. In total, this study is to unfold using four steps. The first step was conducted prior to step 2, 3, and 4. The list below describes each step.

Phase I: (to fulfill requirement of first objective)

Step 1: Literature review: a review of relevant literature was conducted by focusing on the following key words: EETP factors, user friendly EETP factors, Energy Efficient Life styles.

Step 2: Expert input (data collection and data analysis): to validate the results of the literature review, an expert input session implementing Delphi close group discussion was also done.

Phase II: (to fulfill requirement of second objective)

Step 3: Brainstorming (data collection and data analysis): this was to investigate effective BPs towards user friendly EETP factors in a Synthetic session.

Phase III: (to fulfill requirement of third objective)

Step 4: Close Group Discussion-CGD (data collection and data analysis): to implement futuristic study method on the finding of second objective in an expert CGD session, implementing Delphi close group discussion.

In this paper, data analysis of the first phase is presented in follow.

■6.0 DATA ANALYSIS

Mainly, data analysis was conducted based on the three answers presented for three questions corresponding to each objective in different interviews. The questions include;

Q1) Is it a user friendly EETP factor?

Q2) What can you propose as Effective BP to consider this factor?

Q3) Is there a need in the future on the proposed BP based on the four mentioned scenarios?

For question 1, the research conducted expert input session by means of Delphi structured close group discussions.

Delphi method is the most applicable group decision making method which is able to cover ‘non-alternative selection’ decision making which can instruct the CGD¹³. This study used five-point rating scale based on 1 for ‘unacceptable’ to 5 for ‘acceptable’. Respondent(s)’ perception collected based on each life style or TP measured were investigated in literature review.

As the data analysis method, Weighted Sum Method (WSM) was used in this study as a non-structured decision making method¹⁴. The formula (1) was applied for each validation aspect. And formula (2) was applied for validation conclusion. Table 1 indicates a sample-result of Weighted Sum Method (WSM).

$$WSM(a_i) = (\sum_{j=1}^n w_j) a_i, \text{ for } i = 1, 2, 3, \dots, m \quad (1)$$

Where,

‘ w_j ’, referred to assigned weight by decision maker in close group discussion for sub-issue of discussion by participants number ‘j’

‘ a_i ’, is sub-issue of discussion with the given ordering number of ‘i’.

$$WSM(a_i) / WSM(a)_{max} = \text{Consensus in } \% \quad (2)$$

Where,

$WSM(a)_{max}$, refers to maximum sum of possible weight can be given for one sub-issue

Formula (2) indicates the consensus calculation. Albeit, consensus were accepted if more than 70% consensus were observed. One example is presented to calculate consensus using WSM (Table 2).

Table 2 Example of WSM process in the calculation of consensus

Validation Aspects	W_1	W_2	W_3	W_4	W_5	W_6	W_7	SWM	WSM W_{a_max}	Cons. %
factor 1	3	4	5	5	5	np	5	27	30	90

Note . np: refers to cases where participants didn't assigned the weight to the sub-issue, **Cons.:** refers to consensus calculated based on formula (4).

7.0 DISCUSSION AND CONCLUSION

This study identified user friendly EETP factors. Based on literature review, 'life style and TP measures' were presented to the expert to validate their acceptability as user friendly EETP. The data analysis of expert input was conducted using WSM. Based on 70% saturation, the study presented its result with the list of user friendly EETP criteria as presented in Table 3.

Table 3 Content analysis to identify 'user friendly EETP' based on adopted list of life styles

Life styles and TP measures		Q1
Life style	Bike for exercise	61
	Bike on errands	33
	Bike on retail purpose	24
	Change oil in car	60
	Get instruction to increase self-reliance	72
	Exchange goods or services	40
	Grow vegetables	78
	Recycle paper	75
	Recycle glass	34
	Recycle cans	46
	Buy second-hand clothes	24
	Buy at garage sales	65
	Make gifts	78
	Make clothes/furniture	73
	Plan meatless meals	67
	Have compost pile	63
	Contribute to ecology organizations	85
	Belong to a cooperative	83
Plan	Travel coordinator	74
	Promotion and publicity	65
	Implementation process	73
Walking	Improved lighting and walkways	56
	Incentives for walkers	74
	Crossings in/adjacent to site	56
	Changing/shower facilities	36
Cycling	Pool cycles	56
	Bicycle loan scheme	62
	Good, secure parking provision	75
	Discount for purchasing and equipment	68
	Provision of PT information at workplace	75
Public transport	Access to rail planner	32
	Discounted tickets	45
	Liaise with local operators for new service	74
	Pay for new services	54
	Pay for subsidies of existing bus services	83
	Staff travel survey	74
	Priority parking spaces for car sharers	79
	Guaranteed ride home (taxi)	90
Car share	Reduce parking supply	87
	Ration parking through permit allocation	93
	Charge for parking	93
	Flexi-time	66
Parking	Telecommuting/working	98
	Company car initiatives	78

Further development of data analysis will be conducted in this project and will be presented in future papers. The practical approaches on EETP implementation in future road and highway construction will be investigated in further studies. In particular, the physical and structural aspects of road construction need to be studies which have been recommended in previous construction researches, such as, Lee *et al.*¹⁵, Talebi *et al.*¹⁶, and Kueh *et al.*¹⁷.

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